

Dear Colleagues:

I am continuing to think about more effective use of electronic methods for disseminating the results of biomedical research, and am actively seeking additional views and hoping to stimulate wider discourse on the matter. I hope you will read this latest draft of a proposal for a new system for electronic publishing and send me any comments at the e-mail address given above. We will be posting the responses for others to read as well. The draft below was written by me, with active assistance from David Lipman, Director of the National Center for Biotechnology Information (NLM/NIH) and Pat Brown, Stanford University, and with the assistance of several others. -- Harold Varmus

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and June 20, 1999 (ADDENDUM)

E-BIOMED:

A Proposal for Electronic Publications in the Biomedical Sciences

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Prologue

Electronic communication is making dramatic changes in the way information is exchanged among scientists, including biomedical scientists. Over the past decade, steeply increasing numbers of scientists on all continents have abandoned traditional mail and faxes in favor of electronic mail. Many log-on to GenBank and many other data repositories on a nearly daily basis. The titles and abstracts of papers published in most scientific journals are available "on line" from the date of publication and sometimes even before; some full texts can be accessed electronically and downloaded, with or without subscription fees; and convenient, freely accessible resources, such as PubMed (<http://www.ncbi.nlm.nih.gov/PubMed/>), provide powerful engines for searching the biomedical literature. In at least one field, physics, preprints are made freely available electronically to interested readers, through a server called "e-print" (<http://xxx.lanl.gov>). In other fields, including biology, many laboratories maintain World Wide Web pages that offer their colleagues deeper views of the data that support published findings, describe methods in detail, illustrate the most recent talks given by lab members, and serve as important sources of specialized information and links to other Web sites and citations.

Despite these welcome and transforming changes, the full potential of electronic communication has yet to be realized. The scientific community has made only sparing use thus far of the Internet as a means to publish scientific work and to distribute it widely and without significant barriers to access. Informative and even visionary essays have explored this topic (see, for example, articles by

Ginsparg [<http://xxx.lanl.gov/blurb/pg96unesco.html>], Walker [<http://www.amsci.org/amsci/articles/98articles/Walker.html>], and Harnad [<http://www.princeton.edu/~harnad/nature.html>], and references cited therein, as well as other recent proposals [<http://library.caltech.edu/publications/scholarsforum> and <http://www.arl.org/newsltr/202/intro.html>]).

In this essay, we propose a system for electronic publication of new results and ideas in the biomedical sciences. We do this with the conviction that such means of publication can accelerate the dissemination of information, enrich the reading experience, deepen discussions among scientists, reduce frustrations with traditional mechanisms for publication, and save substantial sums of public and private money.

Before describing our proposal, it is important to acknowledge the strengths of the current system for published scientific work, because it has served the scientific community well for over 300 years. Printed journals, particularly the few hundred leading representatives, do more than just transmit results to our community. They subject the reports to peer review and editing, a process that reassures busy readers that papers have been carefully scrutinized and affords the authors an opportunity to improve their work based on the (generally anonymous) advice of their colleagues. The perceived hierarchy of the journals can be useful for conferring status and grounds for career advancement on the authors of papers accepted by the most prestigious journals, and it provides a useful guide to readers besieged by the proliferation of published work. Moreover, current journals often present their reports in attractive formats, bound between colorful covers and accompanied by research commentaries, reviews, and various kinds of news, advertisements, and technical advice. In addition to being conducive to concentrated study, pleasurable reading, and skimming, journals are usually convenient to carry, fitting nicely into briefcases and adapting to activities like riding the subway or sitting on the beach. Finally, their very existence as "periodicals" implies a rhythm that can (in the best of circumstances) stimulate anticipation of forthcoming issues and their contents.

No proposal to change the way scientists publish their results and ideas should ignore these and other virtues of the current system. But we believe that current practices also have many liabilities and that these can be addressed by an evolutionary approach that need not threaten most of the benefits attributable to the print-based publication system that is now in place. More importantly, electronic publication can offer several remarkable benefits that could never be achieved through the current system. Many of these benefits depend on low-cost, barrier-free access by scientists to all of the contributions of their fellow scientists in a conveniently displayed electronic format.

A proposal for E-biomed

In the plan presented here, the National Institutes of Health---through the National Center for Biotechnology Information, a component of the National Library of Medicine at the NIH---would facilitate a community-based effort to establish an electronic publishing site, called "E-biomed" It is important to emphasize at the outset that in no sense would the NIH operate as the owner or rule-maker for this enterprise. We are proposing this plan in an effort to accelerate much-needed public discussion of electronic publication in the United States and abroad and to provide the financial, technical, and administrative assistance to initiate such a program.

In the plan we envision, E-biomed would transmit and maintain, in both permanent on-line and downloaded archives, reports in the many fields that constitute biomedical research, including clinical research, cell and molecular biology, medically-related behavioral research, bioengineering, and other disciplines allied with biology and medicine. The essential feature of the plan is simplified, instantaneous cost-free access by potential readers to E-biomed's entire content in a manner that

permits each reader to pursue his or her own interests as productively as possible. We have attempted to endow the plan with the flexibility necessary for evolution as patterns of use become established and as new opportunities for enriching the system are proposed. And we suggest a mechanism for governance (the E-biomed Governing Board) that involves all of the parties concerned---the scientific community (readers and authors), editors, computer specialists, and funding agencies.

Copyright to reports posted in E-biomed would be retained by the authors, with the provision that intact versions would be freely available for transmission, downloading, and publication. Portions of reports could be reproduced only with the permission of the authors.

Scientific reports in the E-biomed repository would be submitted through either of two mechanisms, as described in more detail in the succeeding sections. (i) Many reports would be submitted to editorial boards. These boards could be identical to those that represent current print journals or they might be composed of members of scientific societies or other groups approved by the E-biomed Governing Board. (ii) Other reports would be posted immediately in the E-biomed repository, prior to any conventional peer review, after passing a simple screen for appropriateness.

(i) Submission to E-biomed through editorial boards

The first of the two mechanisms that authors would use to enter new scientific reports into the E-biomed database is closely aligned with current practice and retains scientific review as a prerequisite to publication. Authors would submit reports electronically to the central server, requesting review by the editorial board of an indicated journal in an appropriate field. If, after review, the report is accepted for publication in either its original or a revised form, the edited version would be posted immediately in E-biomed, and its title and list of authors would appear for a fixed period in the current table of contents for that journal. Later, it would continue to be accessible through the E-biomed search engine or through the journal's home page, annotated with the dates of submission, revision, and acceptance.

If an editorial board judges the report unsuitable for inclusion among its own listings, the authors could resubmit the report for review by another board, defer further attempts to disseminate the findings, or publish in E-biomed through the alternative mechanism described in part (ii).

Electronic publishing provides an opportunity to offer a third outcome to the review process, one that provides a novel solution to one of the most commonly encountered problems in current editorial practice. If a submitted report is deemed by an editorial board to be worthy of attention by some segment of the scientific community, but judged not to meet the criteria set for inclusion among a limited number of prime listings, the editorial board could still accommodate the report by choosing to maintain one or more additional listings. These additional listings might be grouped by specialty or simply designated as a larger, less exclusive version of the primary listing. Authors of reports that meet the criteria set for these listings---which, while less prestigious, still denote review and endorsement by the journal's editorial board --- could then elect immediate posting in E-biomed.

(ii) Submission to E-biomed through the general repository

Authors would also have the option of entering scientific reports directly into the E-biomed repository without soliciting endorsement by the one of its editorial boards.

Before publication in the database, each report would need to be approved by two individuals with appropriate credentials. These credentials, to be established by the E-biomed Governing Board, should be broad enough to include several thousands of scientists, but stringent enough to provide protection of the database from extraneous or outrageous material. (Such credentials might be membership on any approved editorial board or receipt of a research grant from a reputable funding source. The Governing Board would establish mechanisms to ensure that authors need not personally know two validators in order to have their submissions considered for deposition in E-biomed.)

Criteria for approval of reports must be sufficiently firm to guard against gross abuse of the E-biomed repository, but sufficiently flexible to permit rapid posting of virtually any legitimate work. At any time thereafter, the authors would be free to solicit review and endorsement from a specific editorial board as a means to provide greater prestige and visibility to a paper. Alternatively, interest in such reports could be enhanced by attaching to them informative commentaries written by other investigators.

Initially, some authors might hesitate to try this route or might use it only to report information perceived to be difficult to publish in current journals. With experience, however, this mechanism is likely to become commonly employed because of its simplicity, flexibility, and speed; because electronic search engines are much more powerful than visual scanning of tables of contents to find relevant articles; and because other instruments (novel peer review mechanisms, appended commentaries, citation counts, and accession data) can be used to enhance the status and prominence of a report.

Inherent and prospective benefits of E-biomed

We contend that establishment of the E-biomed system would deliver several powerful benefits to the scientific community, with very little risk and with the opportunity to supplement the system with further improvements in the near future. In this section, we describe some of the advantages that we envision.

Open access to scientific reports and assembly of personalized journals

The single greatest attraction of E-biomed is that all of its scientific content will be available without barriers to any user with Internet access. This will maximize the dissemination and use of research results.

All reports filed in E-biomed would be searchable by a single search engine. In this way, all new entries that address topics important to any single reader or laboratory could be highlighted on a routine (even a daily) basis. Readers could also be alerted each time that the editorial boards of greatest significance to them post new selections. E-biomed would allow each user to invent his or her own "virtual" or personalized journal, by downloading the reports he or she would like to read that week. Browsing could be done electronically by scanning tables of contents for selected editorial boards. But it is likely that browsing could also be conducted with printed materials in more comfortable settings, perhaps by using new magazines created as guides to E-biomed or existing journals that add surveys of new E-biomed entries to their current services.

Improved format for publication of modern biology

More general use of electronic publishing through E-biomed would expedite the wider use of

methods of presentation that are now slowly gaining acceptance at web sites and in supplements to print publications. With the dramatic expansion of space, it will be possible to present much larger data sets (including detailed photographs and movies), provide more extensive analysis, and describe methods in the precise detail necessary to recapitulate experiments. Moreover, electronic formats allow layered viewing at increasingly greater levels of detail, so that readers can first get a concise message and then pursue information in proportion to need and interest. Publication in E-biomed would also offer many of the other advantages that are now obvious from the transfer of journal articles into electronically accessible forms: hyperlinks to relevant literature, databases, and websites; registration for future retrieval of related papers by interested readers; and other conveniences.

More rapid dissemination of scientific information

E-biomed would markedly speed up both the review and production processes currently used in scientific publishing. This would be especially so for reports that are entered directly into the E-biomed repository without traditional editorial review. But even those reports reviewed and listed by editorial boards would be available earlier to the reading public because they would all be posted at the time of acceptance, eliminating the lag time now ascribable to publication on paper. Moreover, many fewer reports would be sequentially reviewed by more than one editorial board in order to find a publishing outlet; this too would significantly decrease the time that elapses between the drafting of a report and its transmission to interested readers. It is also likely that more uniform electronic publishing will speed the review period, because electronic methods will probably be more generally employed to submit, transfer, review, alter, and edit the reports. In fact, those editorial boards that develop the most efficient and most accessible review processes will compete most effectively for the best reports.

Reduced costs

Scientific journals are inherently costly. The price of publication and distribution is presently levied on users in a variety of ways: subscriptions to libraries and individual readers for print and electronic versions; page charges to authors; and the time and labor required to maintain and use libraries. (The expenses currently incurred by institutions have recently been the subject of a much publicized scholarly report---accessible at <http://jan.mannlib.cornell.edu/jps/jps.htm>---and have even been held responsible for the decline in publication of academic monographs [see "The New Age of the Book" by Robert Darnham in The New York Review of Books, pp.5-7, March 18, 1999 <http://www.nybooks.com/nyrev/WWWarchdisplay.cgi?19990318005F>].)

While our proposal cannot eliminate all of the costs associated with scientific publishing, movement to an electronic format is likely to reduce those costs dramatically (see an essay by Odlyzko for one account [<http://www.research.att.com/~amo/doc/competition.cooperation.pdf>]).

The most crucial effect of cost reduction would be the opportunity to remove price as a barrier to individuals seeking any of the vast information deposited in E-biomed. It would also offer savings to individuals, laboratories, institutions, funding agencies, and the editors and publishers who move to electronic formats.

Other possibilities

E-biomed is designed to evolve in ways that might affect the way we practice science.

- In an electronic publishing system, it is possible to engage electively in a more open reviewing

process---one in which critiques of the scientific reports are accessible and possibly signed. This development, if widely accepted, could offer many benefits: more responsible reviews, an instructive and ongoing public conversation about published work, and career rewards for useful commentaries about work done by others. These reviews could be part of the vetting process that awards authors with a place on a table of contents of an E-biomed journal or they could be post-publication reviews appended to entries in the general E-biomed repository.

- E-biomed might serve as a communal site for posting notices of meetings and job opportunities; for providing synopses---or even full texts with illustrations---of talks presented at scientific symposia; and for engaging in world-wide discussions of a variety of scientific and political issues.
- Electronic publication could allow the amendment of reports, permitting authors to transmit additional information that might not warrant a separate report. Versions of reports containing supplementary information would be announced and clearly denoted as such, while the original versions are preserved as a 1.0 file for the historical record and downloaded for safekeeping.
- The active E-biomed process might be accompanied by a much-needed effort to convert material already published on paper to digital text and image format, with hyper-linked citations. This additional initiative would ultimately allow all users of E-biomed to move seamlessly through the entire body of reported information in biomedical sciences. And it would also enhance scientific productivity and reduce burdens on library facilities.
- One further, less tangible benefit might also occur as a natural outcome of shared use of E-biomed: a heightened sense of community among biomedical scientists. This might be conducive to the adoption of uniform standards for sharing the data and providing access to the research tools described in E-biomed.

How do we guarantee equity in the new system?

Although the current system of scientific publishing can be criticized for lapses of fairness, it has, in general, served us well. Thus any new system must be developed with concern for the ambitions of trainees, little-known scientists, or scientists at less prestigious institutions or foreign sites. Clearly, electronic communication has enormous advantages for people in all of these categories, because it is a democratizing force that makes distance and wealth nearly irrelevant. However, it is important to ensure that opportunities to enter reports into E-biomed are just as rich as the opportunities to access the reports filed by others. The editorial boards and the Board of Governors will need to give careful attention to this issue; for instance, it will be imperative to provide a means for any author, however remotely located or poorly known, to have access to two "members" of the system to validate reports submitted to the general repository.

How should E-biomed get started?

We offer this proposal---and hope to publish it in a widely read journal---with the goal of stimulating a much broader discussion of electronic publishing before initiating E-biomed. In this way, we hope to engage the editorial boards and publishers of existing journals, members of scientific societies, and the entire scientific community in a vigorous international discussion over the next few months.

Several questions should be addressed, while recognizing that satisfactory answers to some of them can be obtained only by empirical tests of the E-biomed proposal:

- Does the plan make sense? Is it likely to achieve the benefits we ascribe to it? Are there other (better) ways to achieve them?
- How should E-biomed be financed and managed? The NIH is prepared to provide funds and expertise to initiate the project. Should other funding agencies, in the U.S. and abroad, also support it? Or should funds be developed through other mechanisms, such as "submission charges" paid by authors?
- What should be the composition of the E-biomed Governing Board? And how much authority should the Governing Board have over the functions of editorial boards that participate in E-biomed? What responsibilities should the Board have beyond developing rules of operation, producing an annual budget projection, negotiating with groups asking to establish editorial boards, and resolving disputes?

Once these and other questions have been considered, the NIH will publicize an appropriately modified proposal, assemble the Governing Board, and establish the E-biomed site with the Board's guidance.

Summary

The advent of the electronic age and the rise of the Internet offer an unprecedented opportunity to change scientific publishing in ways that could improve on virtually all aspects of the current system. The NIH has addressed this opportunity by proposing a new system, E-biomed, that has many advantages over the existing means of disseminating research findings: open access, greater speed, reduced cost, and enhanced depth of presentation. We now welcome constructive comments from the scientific community, with the intention of putting a suitably revised plan into operation in the near future.

Addendum (June 20, 1999)

A few weeks ago, our description of E-biomed, a proposed electronic publishing system for biomedical research, was circulated widely, reported in *Nature* and *Science*, and posted on the NIH web site. Since then, my colleagues and I have received many comments and questions and engaged in several spirited discussions of the proposed goals and methods with a variety of interested parties. In addition, the proposal has been both criticized and praised in several prominent journals and newspapers. The diversity of opinions and the number of questions suggest that the debate will and should continue for some time. But we believe that it is useful at this point to restate the central issues more clearly and offer responses to the most frequent questions and criticisms.

The core objectives of E-biomed

E-biomed is intended to be a new and more effective means to organize, disseminate, use, and store the information and ideas generated by the international biomedical research community. We envision a system for electronic publication in which existing journals, newly created journals, and an essentially unrestricted collection of scientific reports can be accessed and searched with great ease and without cost by anyone connected to the Internet. In a sense, what we are proposing is an electronic public library of medicine and other life sciences. Journals that participate in the E-biomed system would be expected to exercise expert review and editing functions. The NIH, in conjunction with other organizations, would contribute technical expertise, participate in the development of the governance of the system, and help with financial support.

The system we propose is intended to make knowledge and ideas in life sciences widely and freely accessible to the scientific community and the public, in the tradition of free public libraries. In no sense should E-biomed be interpreted as a proposal to interfere with, control, or restrict the activities of existing journals or other vehicles for transmitting scientific information. Rather it is intended to develop new opportunities to improve the communication of science.

Three elements of the proposal are essential and warrant restatement:

(I) Accessibility: To provide all potential readers with full electronic access to a wide body of life science literature, in a manner that is free of barriers, international in scope, and seamless in operation.

Offering the international scientific community free, fast, and full access to the entire biomedical research literature is the most important goal of our proposal. As originally described, anyone, anywhere, who is connected to Internet can go to a single site at any time and look at the entire biomedical research literature---to search with pertinent terms, inspect the offerings of favorite journals, and download articles for subsequent study. Such access will allow all investigators to make the best and quickest use of the new findings that public and private funding sources around the world have paid for, and it will give citizens of all nations the greatest hope that new information will be efficiently used to understand biological systems and develop effective interventions against disease. With appropriate design of the system's infrastructure and provisions for multiple electronic maintenance sites and hard-copy archives, we can also guarantee the stability of a system on which the entire research community will come to depend.

We believe that such unfettered access to a growing and secure database can be achieved without sacrificing the functions that have served the research community well for many years, including rigorous peer review and discriminating editorial decisions. Moreover, we believe that a richer set of information can be made available within a system that takes full advantage of electronic communication

(ii) Flexibility: To use the full potential of electronic communication to present the findings of the scientific community in a fashion that promotes understanding, encourages discussion, and includes the entirety of relevant information.

Increasing use of electronic methods is already changing the way scientists communicate with each other. But the vast majority of reports are still being written with the intent to publish on paper, thereby limiting the potential utility of electronic methods to advance the dissemination and understanding of science. Preparation of reports explicitly for electronic publishing through E-biomed would allow authors to describe methods in full, to show complete data sets, to make better use of graphics, to invite the attachment of commentaries by interested readers, and to construct reports in a "layered" format that moves from condensed to increasingly detailed descriptions and interpretations. The E-biomed system will also encourage the description of experimental work, from both laboratory and clinical investigators, that lacks definitive or "positive" results and hence is unlikely to be accepted for publication in most current journals; such work, however, is often useful to others contemplating similar experimental approaches and could be readily accommodated within E-biomed.

(iii) "Evolvability": To design a system for electronic publication that is capable of evolving in a variety of directions, so that uncertainties about operation and governance can be resolved through experience.

Because our proposal is ambitious and addresses issues central to the conduct of research, we have tried to incorporate alternative modes of action wherever possible, to allow E-biomed to evolve as we learn from experience and in response to the changes in attitudes and practices that are likely to occur as the system is developed and used. Most obviously, we have offered two methods for posting reports---one that depends on traditional review under the supervision of multiple, independent editorial boards and one that requires only validation that the report meets certain minimal standards. We expect that the vast majority of reports are likely to be submitted through editorial boards, since the biomedical research community relies heavily on the review process for discriminating among a large number of articles. But we also believe that much useful information will be communicated through the "minimal screening" route and that, with time, the community will learn to use this material effectively, in ways suggested in a later section. Such choices allow evolution.

We also expect the governance and financing of the system to evolve. Once an initial advisory group (called the Board of Governors in the initial proposal) has been established, its membership will change as new entities become involved with the project. The overarching rules of operation might also then undergo change. Many aspects of the system, however, would be under the jurisdiction of individual editorial boards and would evolve in accord with the relationships among authors, editors, and readers of each journal. (For example, while we favor the idea that copyright would be retained by authors, editorial boards could choose to hold copyrights; this policy decision might then influence the choice some authors make about the boards to which their reports would be sent for review. Or the means for financing the review and redaction activities of a journal might vary among journals and over time.)

Finally, we expect that the E-biomed system will change the way individual scientists use the scientific literature. This will, in turn, stimulate entrepreneurial activity in the private sector, encouraging the development of printed or electronic guides to interesting new reports in the various fields represented in E-biomed. Such commercial opportunities would also serve the scientific community well, in the manner illustrated by the "value-added" features of some current journals, including reviews of scientific fields, recent articles, and new books.

Responses to the E-biomed proposal

The literally hundreds of written and verbal responses that we have received thus far are too varied to describe individually, but several issues have been repeatedly raised, suggesting (in some instances) a lack of clarity in the original proposal and (in others) substantial policy issues that may be resolved only by further debate, experimentation, and evolution. Perhaps the most impressive message, however, is the widespread recognition of the significance of electronic publishing and the inevitability of its expansion. This suggests that the central questions now are: How rapidly will the expansion occur? And what form will the expanded use assume? The E-biomed proposal attempts to identify the ingredients of an idealized system for disseminating, storing, and retrieving scientific information, including the core qualities of accessibility, flexibility, and "evolvability".

Another important aspect of the response to date has been the diversity of respondents---people from many scientific disciplines; citizens of many countries; editors, publishers, leaders of scientific organizations, governmental officials, and the scientific rank-and-file. The international interest has been especially noteworthy, since we are eager to insure that development of the E-biomed initiative proceeds as a collaborative effort involving many countries and many agencies. In this regard, we have been particularly pleased by the interest shown by leaders of the European Molecular Biology Organization (EMBO) and the European Molecular Biology Laboratory (EMBL). We are discussing a potential partnership with them that would immediately bring an international perspective to the

project, allow technical matters to be developed jointly between the NCBI and the EBI, and encourage other organizations to collaborate in this initiative.

The National Academy of Sciences will conduct its annual workshop on electronic publishing on June 24, and E-biomed will be presented and discussed on that occasion. We also anticipate organizing one or more meetings devoted entirely to E-biomed in the late summer or early fall, but the places, dates, and auspices have yet to be determined.

Considering major concerns

Even before these meetings occur, we believe that it may be helpful to attempt to respond to several criticisms of (and anxieties about) E-biomed that have been expressed by our correspondents. In the following sections, an underlined question is followed by our response.

Will E-biomed eliminate peer-review and existing journals?

This is, most emphatically, not our intention. On the contrary, we are eager to encourage journals, especially those with strong reputations for rigorous reviewing and careful editing, to become part of the system. We believe that this is the outcome that most authors and readers desire. We also expect that prestigious editorial boards will be newly assembled to establish peer-reviewed electronic journals operating within E-biomed.

Why won't E-biomed just achieve in a more complex way what some current journals are already doing through their own electronic publishing efforts?

This question reveals a fundamental misconception about the differences between our proposal and practices now developing in the publishing community. At present, each individual reader or institution must negotiate the cost of timely access to the electronic versions of each journal (or the journals from each society or publisher). These fees may be large and, in some cases, the licensing agreements with institutions include contentious provisions (e.g. a requirement for compensation for any loss of print subscriptions at that institution as a result of the license). In our plan, all prospective readers would have access to any component of the E-biomed repertoire, as soon as it appears in electronic form, without any payments, special terms, or negotiations. The operation of the E-biomed system and its component editorial boards will, of course, entail considerable costs; some methods for paying for these costs are considered below.

Won't E-biomed encourage the deposition of vast quantities of valueless or erroneous information in a public repository?

Recall that E-biomed is proposed to consist of two major components. The first will contain electronic refereed journals, some of which will also occur in print. Since these journals will operate with traditional peer review and editing, the questions that address the quality of the information in E-biomed do not apply to this component. The second, unreviewed component has the great value of putting on the public record a large body of potentially important data that might not otherwise be available to the scientific community and the public. This latter component, however, is thought by some to offer tempting opportunities to disseminate information of marginal value or accuracy. But few scientists would knowingly put such information into the public domain, because it would soon diminish their reputations. (For example, according to Paul Ginsparg, in the several years of experience with e-print, the electronic pre-print file used by physicists, willful deposition of erroneous information has not been a significant problem.) The opportunity for readers to attach comments will provide a means for retrospective evaluation of directly posted reports and further

reinforce the pressure for authors to conform to high scientific standards. Nevertheless, since the life sciences constitute a wide range of fields, some of which have an immediate impact on public health and policy, careful attention to the deposition and retrieval of unreviewed reports may be advisable, especially in the early phases of operation. For instance, the E-biomed advisory board might restrict submissions to certain fields until the system has been tested, or search engines might be designed to survey subsections of the unreviewed component of E-biomed separately. Regardless of other measures, it will be essential to label very clearly which entries in the repository have undergone critical review and editing and which have been deposited without review.

We anticipate that users of E-biomed will eventually learn how to approach information in the repository that is potentially interesting because of its subject matter, but lacks the immediate accreditation conferred by high quality peer review and endorsement by an editorial board. Some readers will be attracted by favorable comments attached to these reports after posting, and others may depend on the mention of such reports in newly created "guides" to E-biomed.. Of course, some readers may choose to ignore the entries in E-biomed that are not included in the listings of journals, especially the first-rank journals, just as many do now. But the option of seeing all available information in a field---including failed experiments, improvements in experimental methods, or unsuccessful clinical trials, often usefully annotated with commentaries posted by others in the same field---is a powerful incentive for those who are willing to look more broadly. At present this is an nearly impossible task, because results are presented in so many journals that are difficult to examine, because they are offered only at individual websites that are not surveyed by convenient search engines, or because they are not publicly available at all.

Isn't E-biomed likely to be construed as a take-over by the U.S. government of an activity that should be international in character and belong in the private sector?

This is an unfortunate misreading of our proposal. We at the NIH seek to improve the dissemination of scientific knowledge, and we are willing to contribute technical assistance and financial support to catalyze useful changes. But we insist that the efforts be international and collaborative in design and practice. Indeed it will fail if the international scientific community is not broadly represented in its operation and governance. The system we have proposed welcomes the participation of existing journals, does not obligate any journals to join, and would not be owned by the NIH or any other component of the U.S. government.

Won't E-biomed undermine the viability of scientific societies by depriving them of significant sources of income currently derived from subscriptions, membership fees, and advertising?

We acknowledge that several important scientific societies currently depend on their journals to raise the revenues that support the journals themselves and various other beneficial activities. But we can envision gradual changes in the operation of scientific societies that would allow them to continue their many functions, including editorial work, without compromising the development of an optimal general system for dissemination of research findings---an outcome that the members of any scientific society will strongly desire. First, for each journal that elects to join E-biomed, the editorial board would need to consider the means available for recovering the costs of reviewing, formatting, and editing the entries in each journal (some of these means are discussed in a subsequent section). Second, some societies may be able to alter their financial planning to compensate for losses due to a transition to an electronic system that operates in the manner proposed for E-biomed. For example, additional revenues could be raised from annual meetings, from workshops organized by the society, or from increased annual fees justified by the many valuable activities performed on behalf of the membership. In the future, additional fund-raising activities might include the production of specialized, annotated collections of material from E-biomed, selected by experts for their colleagues

in a society.

Won't E-biomed place the scientific community at risk of losing vast quantities of published data because of inadequate provisions for archiving?

We view this danger as very remote. New entries would be deposited at "mirror sites" and the entire collection would be in active use at multiple sites. We envision no difficulty in maintaining even the very large database envisioned in the E-biomed proposal, as long as there continues to be economical growth of space available on hard disks. Nevertheless, for additional security, we expect to store all of the contents of E-biomed on back-up tapes, CD-Rom, or long-lived paper at more than one site.

Isn't E-biomed an inappropriate means for publishing clinical research?

Some commentators have expressed concerns that information bearing directly on patient care or public health policies might be accepted uncritically by physicians, other health care providers, or patients themselves, if it appears in the context of E-biomed, thereby subjecting patients to unacceptable risks. We judge these concerns to be misplaced. As is the case presently, the results posted in E-biomed that are most likely to affect health care will have been subjected to critical review and editing by journals. Readers of reports in E-biomed will be clearly informed about how reports are entered in the database, which results have been reviewed and by which editorial board. As everyone knows, a large amount of medically relevant information of highly variable quality is already available on the Internet, but its origins and evaluation are usually much less obvious than will be the case for reports available through E-biomed.

Other respondents have noted that the E-biomed proposal offers some special advantages for the presentation of clinical research findings. These include full access to large data sets; posting of results from inconclusive or "negative" trials of new interventions that might otherwise not be publicly available; and the utility of search engines for surveying a large literature.

How can the E-biomed Governing Board possibly keep track of thousands of reports in many participating journals?

This question reflects a misunderstanding of the relationship we envision between the E-biomed advisory board and the editorial boards participating in the system. The editorial boards of individual journals would continue to maintain surveillance over the reports submitted to them. The advisory group would be responsible for general policies (e.g. to insure interoperability among the member journals) and for the rules that apply to the submissions to the repository of unedited reports.

Won't the screening process for unreviewed reports to be posted in the general E-biomed repository be unfair to those who lack appropriate "contacts"?

Several correspondents have expressed an appropriate concern that the use of members of the scientific community with certain credentials to serve as screeners might create inappropriate barriers to submission. We agree that it might be simpler and more fair to use employed staff for this purpose, since the screening process is not intended to involve critical judgment, simply exclusion of libelous, salacious, or otherwise unsuitable material. These are ultimately matters for the system's advisory board to determine.

How will E-biomed avoid accentuating economic or language-based disparities in the access to the research literature?

Some have argued that E-biomed would further limit the access to the scientific literature accorded to those who work under limited economic circumstances or understand only languages other than English. We acknowledge that such disparities currently exist, but we believe that free access to the scientific literature in electronic form has a much greater prospect of reducing the disparities than do other means. In most parts of the world, a computer with Internet connections is much less expensive and much faster than subscriptions to biomedical journals. Moreover, the Internet and its successors are evolving rapidly and becoming increasingly accessible worldwide, but there is no comparable trend towards inexpensive and rapid access to the scientific literature in print form. Finally, it is reasonable to expect that E-biomed can facilitate efforts to reduce language barriers to scientific communication by freely providing reports in an electronic format suitable for automated or traditional translation.

Unresolved issues that require further study or can be resolved only through experience

We have been asked a number of important questions that are difficult to answer without further work. In this section, we list some of these with brief responses. We anticipate that many of them will be discussed at forthcoming workshops on electronic publishing.

How much will E-biomed cost?

To approach this still unanswered question, it will help to separate the infrastructural costs of E-biomed (the search and retrieval systems, the operating hardware and software, technical help at storage sites, etc.) from the scalable costs of handling peer review, editing, and redaction. We are attempting to determine the likely costs of converting some existing journals into an electronic mode, taking into consideration the costs of reviewing, editing, and redacting. We are also trying to estimate what the NIH, other funding agencies, and individuals currently spend on publication of biomedical research, in the form of subscription fees, page charges, reprint purchases, paper copying, and institutional library costs.

How should funds be raised to pay for the expenses associated with electronic publishing of journals that provide peer review, editorial oversight, and redaction?

This very important issue will need to be thoroughly addressed by the proposed international governing body of E-biomed. Decisions will undoubtedly be influenced by considerations of both philosophy and costs, and many of them will likely be left to individual journals and publishers. One straightforward strategy would be the imposition of fees for authors---perhaps a small fee at the time of submission and a larger one at the time of acceptance. This is consistent with practices that are currently widespread and, if exceptions for authors in financially constrained circumstances are readily allowed, it is likely to be fair. Other options include advertising schemes and distribution of funds provided by research agencies, philanthropies, or industries; these raise a number of complex issues that will require debate.

Who will hold the copyright to articles that appear within edited sites in E-biomed?

Although we favor the notion that authors will retain copyright, this is a matter that could largely be left to individual editorial boards to resolve. The advisory board might, however, want to consider the possibility that some "fair use" policy should be adhered to by all journals participating in the system, even those that choose to retain copyright.

What should E-biomed be called? And what should be its disciplinary boundaries?

E-biomed is a provisional name for the proposed electronic publishing system, not a URL or e-mail address; because it has gained some currency in discussion of the proposal, it should probably not be discarded until an international advisory board is formed and a final name adopted. When this happens, the board will apply to the Library of Congress and other venues for appropriate registration of electronic addresses to avoid conflicts with any other similar names.

We agree with suggestions that our earlier description of the boundaries for E-biomed may appear too narrow; for example, it seems to exclude plant biology. A larger scope, such as life sciences, might be more appropriate, but only a representative advisory board can make authoritative decisions about the disciplines that should be included at the outset. Of course, the boundaries might change over time.

Coda

The conversion of scientific publishing from a paper-based to an electronic format is occurring rapidly. The scientific community has a natural and powerful interest in helping to shape the new means by which its findings and ideas will be transmitted. It is in that spirit that we have made our initial proposal; we hope that the views presented here will continue to promote public discussion of the future of scientific publishing.

[This addendum was prepared by Harold Varmus, in collaboration with David Lipman and Pat Brown, with helpful advice from Fotis Kafatos, Frank Gannon, Tony Fauci, and several others.]